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Signed R. Mahoney

Dated 20 MAR 2002

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Patents Form 1/77

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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

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P01/7700 The Patent Office 0.00-0100104.9

THE PATENT OFFICE
LONDON
-3 JAN 2001
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Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference — TJF/JY/33972

2. Patent application number *(The Patent Office will fill in this part)* — **0100104.9** — 3 JAN 2001

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

FLIGHT REFUELLING LIMITED
BROOK ROAD
WIMBORNE
DORSET BH21 2BJ

Patents ADP number *(if you know it)* 45162500[illegible]

If the applicant is a corporate body, give the country/state of its incorporation — UNITED KINGDOM

4. Title of the invention — SUBSEA PIPELINE POWER TRANSMISSION

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

fJ CLEVELAND
40-43 CHANCERY LANE
LONDON
WC2A 1JQ

Patents ADP number *(if you know it)* 07368855001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	–
Description	7
Claim(s)	–
Abstract	–
Drawing(s)	1

10. If you are also filing any of the following, state how many against each item.

Priority documents	–
Translations of priority documents	–
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	–
Request for preliminary examination and search *(Patents Form 9/77)*	–
Request for substantive examination *(Patents Form 10/77)*	–
Any other documents *(please specify)*	–

11. I/We request the grant of a patent on the basis of this application.

Signature FJ Cleveland Date 3.01.01

fJ CLEVELAND

12. Name and daytime telephone number of person to contact in the United Kingdom: TJ FAULKNER 020 7405 5875

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Subsea pipeline power transmission

This invention relates to subsea pipeline power transmission systems, methods and apparatus.

The term subsea is used in this application as this is conventional technology, however, it will be understood that this covers any underwater situation.

In many circumstances where subsea pipeline systems are used, there is a desire to operate equipment at locations which, in the general sense, are remote. That is to say, although the equipment is situated adjacent to the pipeline itself it is not near any other facility or infrastructure. Such pieces of equipment might, for example, be sensors which monitor the integrity or operation of the pipeline system.

One of the problems with such remote pieces of equipment is providing a suitable power source. Whilst batteries can be used these are unattractive for various reasons including their limited life, their expense and environmental concerns.

It is an object of the present invention to provide methods, systems and

apparatus which allow the supply of power to remote equipment in subsea pipeline systems.

According to a first aspect of the present invention there is provided a subsea pipeline power transmission system comprising a pipeline, an electrical power supply connected to the pipeline at a first location, and connection means provided on the pipeline at a second location for connection of a load to the pipeline to allow the load to receive electrical power from the power supply via the pipeline wherein the pipeline has a plurality of cathodic protection anodes, each of which is electrically connected via respective impedance means to the pipeline.

According to a second aspect of the present invention there is provided a method of subsea pipeline power transmission along a pipeline having a plurality of cathodic protection anodes comprising the steps of:

applying electrical power to the pipeline at a first location; and

electrically connecting a load to be supplied to the pipeline at a second location;

wherein each anode is electrically connected via respective impedance means to the pipeline.

According to a third aspect of the present invention there is provided apparatus for use in a subsea pipeline power transmission system or method comprising:

an anode arrangement comprising, a sacrificial anode arranged for mounting on a pipeline and impedance means having one terminal connected to the anode and another terminal arranged for connection to said pipeline; and

an electrical power supply arranged for electrical connection to a pipeline.

According to a fourth aspect of the present invention there is provided an anode arrangement for use in a subsea pipeline power transmission system, the arrangement comprising, a sacrificial anode arranged for mounting on a pipeline and impedance means having one terminal connected to the anode and another terminal arranged for connection to said pipeline.

The anode arrangement may include further terminals allowing the connection of a load across the impedance means.

The impedance means may comprise inductance means. Preferably the impedance means comprises filter means. The impedance means, especially when comprising filter means, may be arranged to give a high impedance to time varying signals within one or more selected ranges of frequencies and a

low impedance to signals outside the selected range or ranges. The impedance means can be arranged so that the real part of the impedance is substantially zero. This means that there is little or no attenuation of the dc components of signals passing through the impedance means.

The use of inductance means and particularly filter means has advantages when the metallic structure is used to carry power currents because these means can be chosen to offer high impedance to the time varying signals used for power supply thereby reducing losses, whilst offering low impedance to the currents used for cathodic protection. Minimising losses is particularly important when transmitting power rather than merely trying to detect a signal. Limiting loss to a realistic level is necessary to give a practical system.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawing which schematically shows a pipeline system embodying the invention.

The drawing shows a subsea pipeline system which comprises a pipeline 1 provided with a plurality of anodes 2 which are electrically connected to the pipeline 1 via respective filter means 3.

A power supply 4 is electrically connected to the pipeline 1 towards one end. This location will typically be at a main facility or some other place provided with good infrastructure such that the provision of a power supply 4 is not problematic.

Although not shown in detail, as is common practice in this field, the pipeline system is provided with a cathodic protection system of which the anodes 2 form an essential part. Cathodic protection currents flowing in the pipeline 1 to improve corrosion resistance will be dc currents. Thus, the filter means 3 provided at each anode are arranged to have substantially zero impedance to dc currents.

On the other hand, the filter means 3 are arranged to have a very high impedance to the power supply currents delivered by the power supply means 4. In this system the power supply means applies a current typically having a frequency in the order of 30 to 100 Hz. The filter means 3 are arranged to have a high impedance to signals having the appropriate frequencies in this range. The filter means 3 may be designed so that at the transmission frequency it gives an impedance of at least two orders of magnitude greater than the characteristic impedance of the pipeline (with anodes removed) when acting as a transmission system. This means that whilst the cathodic protection currents

can flow to the anode substantially unimpeded, the losses from the pipeline 1 as far as the power supply current is concerned are greatly reduced.

The frequency of current used to transmit power is chosen with regard to two main factors. Lower frequencies call for more bulky and expensive components in the filter means whereas as frequency is increased, skin effect in the pipeline becomes problematic. The frequency at which skin effect begins to compromise performance may be determined empirically on a test length of pipe but can be expected to be in the range of 50 to 100 Hz for most typical pipes.

The above arrangement means that loads 5, i.e., pieces of equipment which need electrical power, can be connected to the pipeline 1 at locations which are remote from the power supply 4. As shown in the drawing, a load 5 may, for example, be connected directly to the pipeline 1 and provided with a separate earth terminal E, or may be connected directly across one of the filter means 3 associated with a particular anode 2 where the equipment to be driven is located at or near an anode 2.

The provision of suitable impedance means, preferably as in this embodiment filter means 3, between the pipeline 1 and the anode 2 makes a power supply system of this type feasible. For example, if no impedance means 3 are

provided, then power supply in this manner might be possible in a subsea pipeline over a distance of say only 300 to 400 metres. However, with the filter means included, it can be possible to transmit power over a distance of say 10 kilometres. In the present system the loss of power might typically be in the order of 0.5 to 1dB per kilometre and as such, if the power supply 4 applies 150 watts to the pipeline 1 then a load at a 10 kilometre distance from the power supply 4 should be able to draw a power in the order of 50 to 15watts. It has been determined that effectively stopping leakage from the anodes gives a 10^4 improvement in power transmission capabilities over 10 kilometre subsea pipelines.

It will be appreciated that although an ac current is applied to the pipeline 1 for transmission, this signal may be locally converted into a dc signal using known techniques if this is required.

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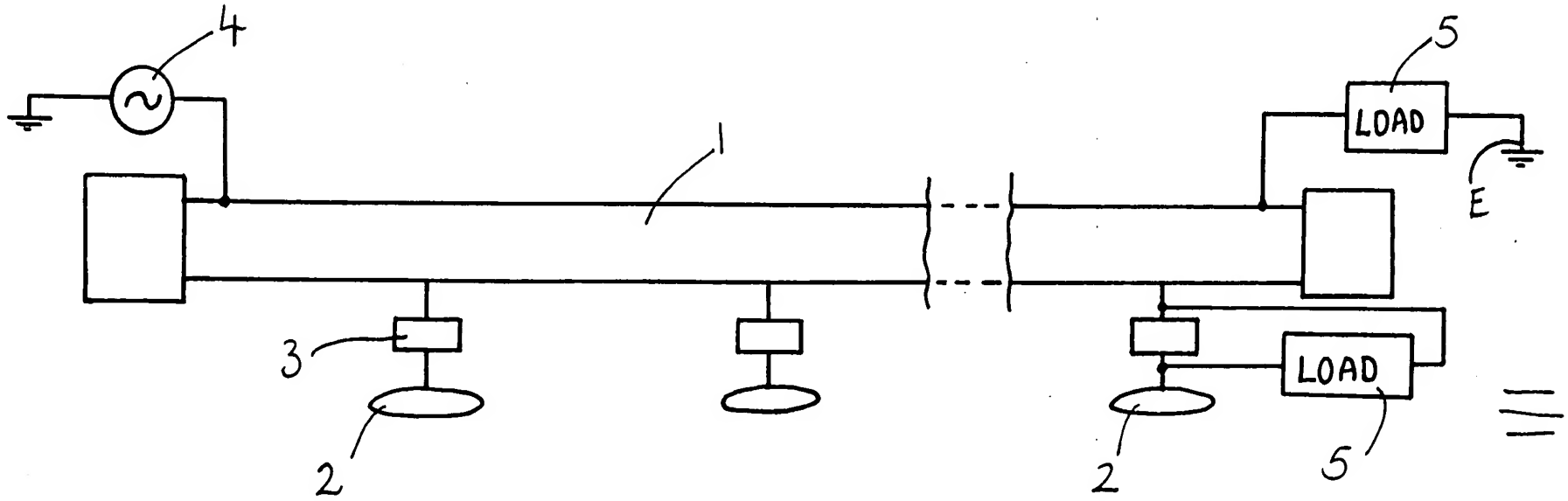
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